

10 May 1978

## MILITARY SPECIFICATION

SEMICONDUCTOR DEVICE, TRANSISTOR, SILICON  
TYPE 2N3904

This specification is approved for use by the Electronics Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers the detail requirements for NPN, Silicon, Plastic encapsulated transistor, designed for general switching and amplifier applications.

1.2 Outline and Dimensions. See Figure 1 herein.

1.3 Maximum Ratings. (At  $T_A = +25^\circ\text{C}$ , unless otherwise specified).

$P_T$	$\theta_{J-C}$	$V_{CB}$	$V_{CE}$	$V_{EB}$	$I_C$	$T_{op}$ and $T_{stg}$
MW	MW/°C	Vdc	Vdc	Vdc	mAdc	°C
350	2.73	60	40	6	200	-55 to +150

1.4 Primary Electrical Characteristics. (At  $T_A = +25^\circ\text{C}$ ).

	$h_{FE}$			$C_{obo}$	/hfe/	NF	Switching Times	
	$I_C=.1\text{mA}$ $V_{CE}-1\text{V}$	$I_C=10\text{mA}$ $V_{CE}-1\text{V}$	$I_C=100\text{mA}$ $V_{CE}-1\text{V}$	$F=1\text{MHz}$ $V_{CB}=5\text{V}$ $I_E=0$ pf	$f=1.0\text{ KHZ}$ $I_C=1\text{ MA}$ $V_{CE}=10\text{Vdc}$	$f=10-15.7$ KHZ $I_C=100\mu\text{A}$ $V_{CE}=5\text{V}$ $R_s=1\text{kohms}$ db	$V_{CC}=3.0\text{Vdc}$ $I_C=10\text{ mAdc}$ $I_B=1\text{ mAdc}$ $T_{on}\text{ ns}$ $T_{off}\text{ ns}$	
MAX	40	100	30		100			
MIN		300		4	400	5	70	250

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, US Army Electronics Command, ATTN: DRSEL-RD-TS-S, Fort Monmouth, NJ 07703, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

2 APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein.

SPECIFICATION

MILITARY

MIL-S-19500 - Semiconductor Devices, General Specification for

STANDARDS

MIL-STD-202 - Test Methods for Electronic And Electrical Component Parts

MIL-STD-750 - Test Methods for Semiconductor Devices

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

3 REQUIREMENTS

3.1 General. Requirements shall be in accordance with MIL-S-19500, and as specified herein.

3.2 Abbreviations, symbols, and definitions. The abbreviations, symbols, and definitions used herein are defined in MIL-S-19500.

3.3 Design, construction, and physical dimensions. Transistors shall be of the design, construction, and physical dimensions shown on Figure 1. The devices covered by this specification shall be encapsulated in a plastic material which polymerizes to a rigid condition by virtue of a chemical cross-linking mechanism. Information covering the material(s) used shall be included with the qualification design data to the qualifying activity. Paragraph 3.6.1 of MIL-S-19500 does not apply to the devices covered by this specification.

3.4 Performance characteristics. Performance characteristics shall be as specified in Table I, II and III.

3.5 Marking. The following marking shall be applied:

- a. Type designation or code identification
- b. Manufacturer's identification and date code

4 QUALITY ASSURANCE PROVISIONS

4.1 The transistor covered by this specification (2N3904) is not intended to be certified at a higher quality level than JAN.

4.2 Qualification and acceptance inspection shall be in accordance with MIL-S-19500 quality assurance provisions, and as otherwise specified herein. Groups A, B & C inspection shall consist of the examinations and tests specified in Table I, II & III respectively. The LTPD specified for a Subgroup in Tables I, II & III shall apply for all of the tests combined, in the subgroup. Sample units subjected to Group B, Subgroup 4 and 5 tests, shall not be delivered on the contract or order. Sample units that have been subjected to and have passed Group B, Subgroups 1, 2, 3 and 6 Tests. (These tests to be considered non destructive), may be delivered on the contract or order provided that, after Group B inspection is terminated, those sample units are subjected to and pass Group A inspection. Defective units from any sample group that may have passed group inspection shall not be delivered on the contract or order until the defect(s) has been remedied to the satisfaction of the contractor.

#### 4.3 Particular Examination and Test Requirements:

4.3.1 All electrical test measurements shall be made at room ambient, free-air, temperature of  $+25^{\circ} \pm 3^{\circ}\text{C}$  unless otherwise specified herein.

4.3.2 All applicable end-point test measurements shall be made, wherever possible, within four (4) hours, after the particular sample units have been subjected to the required physical-mechanical or environmental test(s). This "interval" requirement shall not be applicable to measurements specified to be made during (subjection of sample units to) a physical-mechanical or environmental test and shall not be applicable where otherwise specified for life test(s).

4.3.3 Except for intentionally deforming, mutilating, or dismembering mechanical-stress tests to which samples are subjected, there shall be no evidence of mechanical damage to any sample unit after any of the Group A, B or C tests.

4.3.4 The markings shall be legible after salt atmosphere corrosion test. There shall be no evidence (when examined with no magnification) of flaking or pitting of the finish or corrosion that will interfere with the mechanical and electrical applications of the device.

4.3.5 End-point test measurements bias moisture resistance test shall be initiated no sooner than twelve (12) hours and completed no later than forty-eight (48) hours after removal from moisture test. Prior to measurement devices must be stored in an air-conditioned room. At no greater than  $25^{\circ}\text{C}$ .

4.3.6 For the high temperature bias life test, after 1000 hours of test and prior to end-point test measurements, the devices will be allowed to cool to  $25^{\circ}\text{C}$  with the C-B voltages applied during the entire time. Within 48 hours after reaching  $25^{\circ}\text{C}$ , voltages will be removed and end-point measurements made.

4.3.7 Group A inspection shall consist of the examination and test specified in Table I. Group B inspection shall consist of the examination and test in Table II. Group C shall consist of the examination and test in Table III.

4.3.8 For the steam pressure test, devices will be submitted to a steam pressure chamber at 15 psig  $\pm$  2 psig for 96 hours. Devices will be suspended above the water (deionized) which will be of sufficient quantity to permit 96 hours of continuous testing. Remove devices from chamber. Proceed as Para. 4.3.5.

4.3.9 External Visual: Samples shall be inspected up to 6x magnification with direct and oblique light for the following defects:

4.3.9.1 Holes or voids in the encapsulant greater than 0.025 inch in any direction.

4.3.9.2 Cracks in the encapsulant which touch any lead.

4.3.9.3 More than one sharp bend along any lead.

4.3.9.4 Flash on the body of the package greater than 0.025 inch or any protrusion which causes the device to be larger than the outline drawing dimensions.

4.3.9.5 Flash down the leads more than 0.05 inch

4.3.9.6 Flashing of lead metallization.

4.3.9.7 Any stain, ink or encapsulant spots on the leads larger than two lead diameters.

TABLE I - Group A Inspection

Examination or Test	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		Units
					Min	Max	
Subgroup 1 Visual and Mechanical Examination	2071		10				
Subgroup 2 Collector-to- Base Cutoff Current	3036.1	Bias Cond. D $V_{CB} = 30 \text{ Vdc}$ $I_E = 0$	5	$I_{CBO}$	--	30	nAdc
Emitter-to- Base Cutoff Current	3061.1	Bias Cond. D $V_{EB} = 3 \text{ Vdc}$ $I_C = 0$		$I_{EBO}$	--	30	nAdc
Collector-to Base Breakdown Voltage	3001.1	Bias Cond. D $I_E = 10 \text{ uAdc}$ $I_C = 0$		$BV_{CBO}$	60	--	Vdc
Emitter-to Base Breakdown Voltage	3026.1	Bias Cond. D $I_E = 10 \text{ uAdc}$ $I_C = 0$		$BV_{EBO}$	6.0	--	Vdc
Collector-to Emitter Break- down Voltage	3011.1	Bias Cond. D $I_C = 1 \text{ mAdc } \underline{2/}$ $I_B = 0$		$BV_{CEO}$	40	--	Vdc
Static Forward- Current Trans- fer Ratio	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 0.1 \text{ mAdc } \underline{2/}$		$h_{FE}$	40	--	
Static Forward- Current Trans- fer Ratio	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 1.0 \text{ mAdc } \underline{2/}$		$h_{FE}$	70	--	
Static Forward Current Trans- fer Ratio	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 10 \text{ mAdc } \underline{2/}$		$h_{FE}$	100	300	

See footnotes at end of table.

TABLE I - Group A Inspection (Cont'd)

Examination or Test	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		Units
					Min	Max	
Static Forward Current Transfer Ratio	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 50 \text{ mAdc } \underline{2}/$		$h_{FE}$	60	--	
Static Forward Current Transfer Ratio	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 100 \text{ mAdc } \underline{2}/$		$h_{FE}$	30	--	
Base-to-Emitter Saturation Voltage	3066.1	$I_C = 10 \text{ mAdc}$ $I_B = 1.0 \text{ mAdc } \underline{2}/$		$V_{BE}(\text{SAT})$	0.65	0.85	Vdc
Base-to-Emitter Saturation Voltage	3066.1	$I_C = 50 \text{ mAdc}$ $I_B = 5.0 \text{ mAdc } \underline{2}/$		$V_{BE}(\text{SAT})$	--	0.95	Vdc
Collector-to-Emitter Saturation Voltage	3071	$I_C = 10 \text{ mAdc}$ $I_B = 1.0 \text{ mAdc } \underline{2}/$		$V_{CE}(\text{SAT})$	--	0.2	Vdc
Collector-to-Emitter Saturation Voltage	3071	$I_C = 50 \text{ mAdc}$ $I_B = 5.0 \text{ mAdc } \underline{2}/$		$V_{CE}(\text{SAT})$	--	0.3	Vdc
<u>Subgroup 3</u>			10				
Open-Circuit Output Capacitance	3236	$V_{CB} = 5.0 \text{ Vdc}$ $I_E = 0$ $f = 1.0 \text{ MHz}$		$C_{obo}$	--	4.0	pf
Small-Signal Short-Circuit Forward-Current Transfer Ratio	3306.2	$V_{CE} = 10 \text{ Vdc}$ $I_C = 1.0 \text{ mAdc}$ $f = 1.0 \text{ kHz}$		$h_{fe}$	100	400	
Noise Figure	3246.1	$V_{CE} = 5.0 \text{ Vdc}$ $I_C = 100 \text{ uAdc}$ $R_s = 1.0 \text{ k}$ $f = 10 \text{ Hz to } 15.7 \text{ kHz}$		NF	-	5.0	dB

See footnotes at end of table.

TABLE I - Group A Inspection (Cont')

Examination or Test	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		Units
					Min	Max	
Extrapolated Unity Gain Frequency	3261.1	$I_C = 10 \text{ mAdc}$ $V_{CE} = 20 \text{ Vdc}$ $f = 100 \text{ MHz}$		$f_t$	300	--	MHz
Input Capacitance	3240.1	$V_{BE} = 0.5 \text{ Vdc}$ $I_C = 0$ $f = 1.0 \text{ MHz}$		$C_{ibo}$	--	8.0	PF
Subgroup 4 <sup>3/</sup>			15				
Delay Time	3251.1	$V_{CC} = 3.0 \text{ Vdc}$ $V_{BE}(\text{OFF}) = 0.5 \text{ Vdc}$		$t_d$	--	35	ns
Rise Time		$I_C = 10 \text{ mAdc}$ $I_{R1} = 1.0 \text{ mAdc}$		$t_r$	--	35	ns
Storage Time		$V_{CC} = 3.0 \text{ Vdc}$ $I_C = 10 \text{ mAdc}$		$t_s$		200	ns
Fall Time		$I_{B1} = 1 \text{ B}_2 =$ $1.0 \text{ mAdc}$		$t_f$	--	50	ns
Subgroup 5			2				
Pulsed $V_{BE(f)}$	4011.3	$I_B = 500 \text{ mAdc}$ $t = 300 \text{ us}$ Duty Cycle 2.0%		$V_{BE(f)}$		1.45	V

1/See Para. 4.3

2/ Pulse Test: Pulse Width  $\leq 300 \text{ us}$ ; Duty Cycle  $\leq 2.0\%$ 

3/ Test Circuits and Procedure Per Fig. 2 herein

TABLE II - Group B Inspection

Examination or Test 1/ 2/	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		Units
					Min	Max	
<u>Subgroup 1</u>							
Physical Dimen- sions	2066		20				
<u>Subgroup 2A</u>							
Solderability (Omit Aging)	2026	1 Cycle	15				
<u>Subgroup 2B</u>							
Thermal Shock (Glass Strain)	1056.1	Test Cond. B (30 Cycles)	5				
Temperature Cycling	1051.1	Test Cond. F Except Low Temp -55°C					
<u>End-Point Test</u>							
Static forward current transfer ratio 3/ 6/ forward voltage	3076.1	$V_{CE} = 1.0 \text{ Vdc}$ $I_C = 10.0 \text{ mAdc}$		$h_{FE}$	100	300	
	4011.3	$I_B = 200 \text{ mAdc}$ $T_A = 100^\circ\text{C}$		$V_{BE(f)}$		2.0	Vdc
<u>Subgroup 3</u>			15				
Lead Fatigue End-Point Tests Same as Subgroup 2 above	2036.3	Test Cond. E					
<u>Subgroup 4</u>							
High tempera- ture Bias life 4/	1031.4	$T_{stg} = 150^\circ$ $V_{CB} = 45 \text{ Vdc}$ $t = 1000 \text{ hours}$	$\lambda = 15$				
<u>End-Point Test</u>							
Collector-to- Base Cutoff Current 3/	3036.1	Test Cond. D $V_{CB} = 30 \text{ Vdc}$		$I_{CBO}$		50	nAdc
Forward Voltage	4011.3	$I_B = 200 \text{ mAdc}$		$V_{BE(f)}$ $\Delta V_{BE(f)}$ 7/		2.0 200	Vdc mVdc
Forward Current	3076.1	$I_C = 10 \text{ mAdc}$					
Transfer Ratio		$V_{CE} = 1.0 \text{ Vdc}$		$\Delta h_{FE}$ 7/		$\neq 35$	%

See footnotes at end of table.



TABLE II - Group B Inspection (Cont'd)

Examination or Test <u>1/</u> <u>2/</u>	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		Units
					Min	Max	
Subgroup 5 Bias moisture resistance <u>5/</u>  <u>End-Point Test</u>	1021.1	$T_A = 85^\circ\text{C}$ $RH = 85\%$ $t = 1000$ hours $V_{CEO} = 30$ Vdc	$\lambda = 15$				
Collector-to base-cutoff Current	3036.1	Test Cond. D $V_{CB} = 30$ Vdc		$I_{CBO}$	--	.50	$\mu\text{Adc}$
Forward Voltage <u>3/</u>	4011.3	$I_B = 200$ mAdc		$V_{BE}(f)$		2.0	Vdc
Forward Current Transfer Ratio	3076.1	$I_C = 10$ mAdc $V_{CE} = 1.0$ Vdc		$\Delta h_{FE}$ <u>7/</u>		$\pm 35$	%
Subgroup 6 Steady State Operation Life <u>8/</u>  <u>End-Point Test</u> Same as Subgroup 5	1026.3	$V_{CB} = 20$ Vdc MIN $P_D = 350$ mW MAX $T_A = 25^\circ\text{C}$ $T = 100$ hours	$\lambda = 7$				

1/ See Para. 4.3.22/ See Para. 4.3.33/ Pulse Test: Pulse Width  $\leq 300$   $\mu\text{s}$   
Duty Cycle  $\leq 2.0\%$ 4/ See Para. 4.3.65/ See Para. 4.3.56/ Read within 48 hours MAX7/ Change from initial value8/ Test conditions to be varied within limits specified to obtain  
 $T_J = 135^\circ\text{C}$  (Calculated)

TABLE III - Group C Inspection 1/

Examination or Test	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		UNITS
					MIN	MAX	
<u>Subgroup 1</u>			7				
Steam pres- sure	3,4/	p = 15 psig <u>2</u> psig T = 121°C t = 96 hours DI Water 10M					
<u>End-Point Tests:</u> Same as Subgroup 5, Table II							
<u>Subgroup 2</u>			15				
Salt atmosphere (Corrosion)	1041	T= 72 hours					
<u>End-Point Tests:</u> Same as Subgroup 5, Table II							
<u>Subgroup 3</u>			15				
Shock	2016	1500 G, 0.5 msec, 5 Blows each, Orientations X1,Y1, Y2,Z1					
Constant acceleration	2006						
Centrifuge		20,000G					
Vibration variable frequency	2056	(One cycle)					
<u>End-Point Tests:</u> Same as Subgroup 2 Table II							
<u>Subgroup 4</u>			20				
Flammability (external flame) <u>2/</u>							
<u>End-Point Tests:</u> Mechanical and Visual Inspection							

See footnotes at end of table.

1/ MIL-S-19500/529 (EL)  
(cont'd)

TABLE III - Group C Inspection

Examination or Test	Test Method per MIL-STD-750	Conditions	LTPD	SYM	Limits		UNITS
					MIN	MAX	
Subgroup 5 Resistance to solvents		MIL-STD 202 Test Method 215	20				
End-Point Test Visual		Markings shall have remained legible					

1/ Periodicity (every nine (9) months).

2/ Self-extinguishing within 10 seconds, per MIL-STD-202, Test method 111).

3/ Read within 48 hours maximum.

4/ See paragraph 4.3.8.

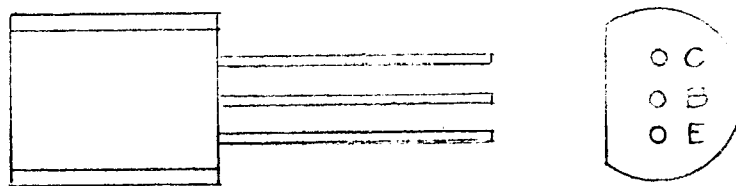
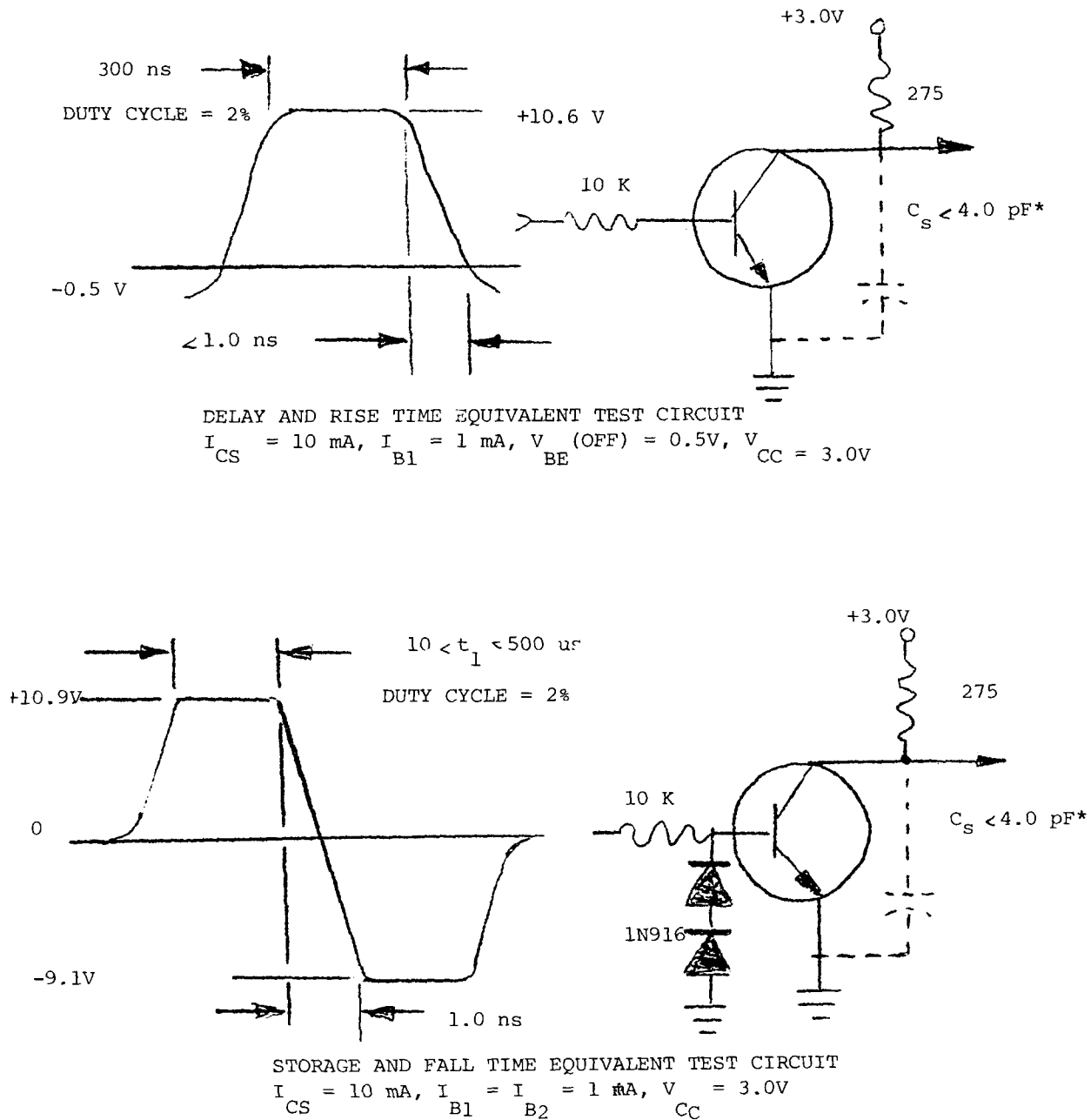


Figure 1. Outline of transistor type 2N3904.

This is a TO-92 case, except the following notes apply:

Note 1; Mounting Height shall be .170" min. .185" max.

Note 2; Flash may be present on device to a height of 0.05" max.

Figure 2. Switching test circuits.

\* TOTAL SHUNT CAPACITANCE OF TEST FIXTURE AND CONNECTORS.

5. PACKAGING

5.1 Packaging requirements. Packaging shall be in accordance with MIL-S-19500.

6. NOTES

6.1 Notes. The notes specified in MIL-S-19500 are applicable to this specification

Custodian:  
Army - EL

Preparing activity:  
Army - EL

(Project 5961-A719)

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